

embodiments the entire top portion 24A has increased adhesion. The increased adhesion is defined by a granule loss of less than 0.8 grams when the roofing material is soaked in water for seven days and then tested by ASTM Method D4977. The increased adhesion can be obtained, for example, by modifying the asphalt with certain polymers such as synthetic rubbers, e.g., SBS rubber.

However, since a coating having increased adhesion is usually more costly than a typical coating, the cost is limited by using a coating not having the increased adhesion in the bottom portion 24C of the coating. In some embodiments, the mat portion 24B also does not have the increased adhesion.

As shown in Fig. 4, resistance to tear/puncture caused by hail impact is improved by using an asphalt-based coating having increased toughness in the bottom portion 44C of the coating 44. It has been found that increasing the toughness of the bottom portion of the coating by itself is sufficient to reduce the occurrence of tears and punctures caused by hail impact. Consequently, the top portion 44A of the coating does not require the increased toughness.

Specifically, the bottom portion of the coating has an increased toughness compared to the top portion, such that the roofing material has an increased impact resistance of at least one UL 2218 class compared to the same roofing material having a bottom portion of the coating with the same toughness as the top portion. In some embodiments, the mat portion 44B also does not have the increased toughness.

The improved impact resistance of the roofing materials is demonstrated by the use of a standard method, UL 2218, "Standard for Impact Resistance of Prepared Roof Covering Materials", Underwriters Laboratories, May 31, 1996.

In this method, the roofing material is secured to a test deck, and a steel ball is dropped vertically through a tube onto the upper surface of the roofing material. The roofing material can be tested at four different impact force levels: Class 1 (the lowest impact force) through Class 4 (the highest impact force). The force

of impact in the different classes is varied by changing the diameter and weight of the steel ball, and the distance the ball is dropped. For example, the Class 1 test uses a steel ball having a diameter of 1.25 inches (32 mm) weighing 0.28 pounds (127 g) that is dropped a distance of 12 feet (3.7 m), while the Class 4
5 test uses a steel ball having a diameter of 2 inches (51 mm) weighing 1.15 pounds (521 g) that is dropped a distance of 20 feet (6.1 meters). After the impact, the roofing material is inverted and bent over a mandrel in both the machine and cross directions, and the lower surface of the roofing material is examined visually for any evidence of an opening or tear. A 5X magnification
10 device may be used to facilitate the examination of the roofing material. If no evidence of an opening is found, the roofing material passes the impact resistance test at the UL 2218 class tested. Preferably, the roofing material has an increased impact resistance of at least two UL 2218 classes. More preferably, the roofing material meets a UL 2218 Class 4 impact resistance standard.

15 The increased toughness of the bottom portion of the coating can be obtained, for example, by modifying the asphalt with certain polymers, such as synthetic rubber or ethylene vinyl acetate.

The bottom portion of the coating with increased toughness, and the top portion of the coating with increased adhesion, can be used together or separately
20 in a roofing material to provide their respective benefits.

In one embodiment of the invention, at least the top surface of the top portion of the coating has increased adhesion to prevent granule loss, as described above. For example, the top portion of the coating may be made with a polymer-modified asphalt to increase its adhesion. Optionally, a layer of an
25 adhesive material can be applied to the top surface of the coating to further improve the granule adhesion. The bottom portion of the coating does not have the increased adhesion. A web is fused to the bottom portion of the coating. The web improves the impact resistance of the roofing material as described above.

The roofing material has an increased impact resistance of at least one UL 2218 class compared to the same roofing material without the web. Suitable webs for improving the impact resistance of a roofing material are described in U.S. Patent No. 6,228,785, issued May 8, 2001, which is incorporated by reference in its entirety.

Some preferred embodiments of the asphalt-based roofing materials of the invention are produced by a coating process that applies the top coating independently of the mat coating and the bottom coating, or that applies the bottom coating independently of the mat coating and the top coating (e.g., in the embodiment relating to a tougher bottom coating). Figs. 5-7 illustrate several different embodiments of preferred continuous processes according to the invention for coating roofing materials.

As shown in Fig. 5, a continuous mat 50 is moved continuously along a path, indicated by the arrows. The mat has a first surface 52 and a second surface 54. In the illustrated embodiment, the first surface is a bottom surface 52 of the mat, and the second surface is a top surface 54 of the mat. As used herein, "top surface" and "bottom surface" refer to the orientation of the mat surfaces in the roofing material which is prepared using the mat.

In the embodiment shown in Fig. 5, the mat 50 is inverted before the first coating operation so that the bottom surface 52 is oriented upward when applying the first coating to the bottom surface. In the illustrated embodiment, the mat is inverted by passing the mat around a first roll 56 and a second roll 58.

In a first coating operation, indicated generally at 60, a first asphalt-based coating 62 is continuously applied to the bottom surface 52 of the mat 50 in a manner so that the first coating saturates the mat and forms a layer on the bottom surface. In the embodiment shown, the first coating operation comprises moving the mat through a gap 64 between an upper squeeze roll 66 and a lower squeeze roll 68. The first coating 62 is supplied to a location before the gap and above